



US Air Force

Environmental Restoration Program – Optimization and Sustainable Remediation

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Air Force Center for Engineering and the Environment

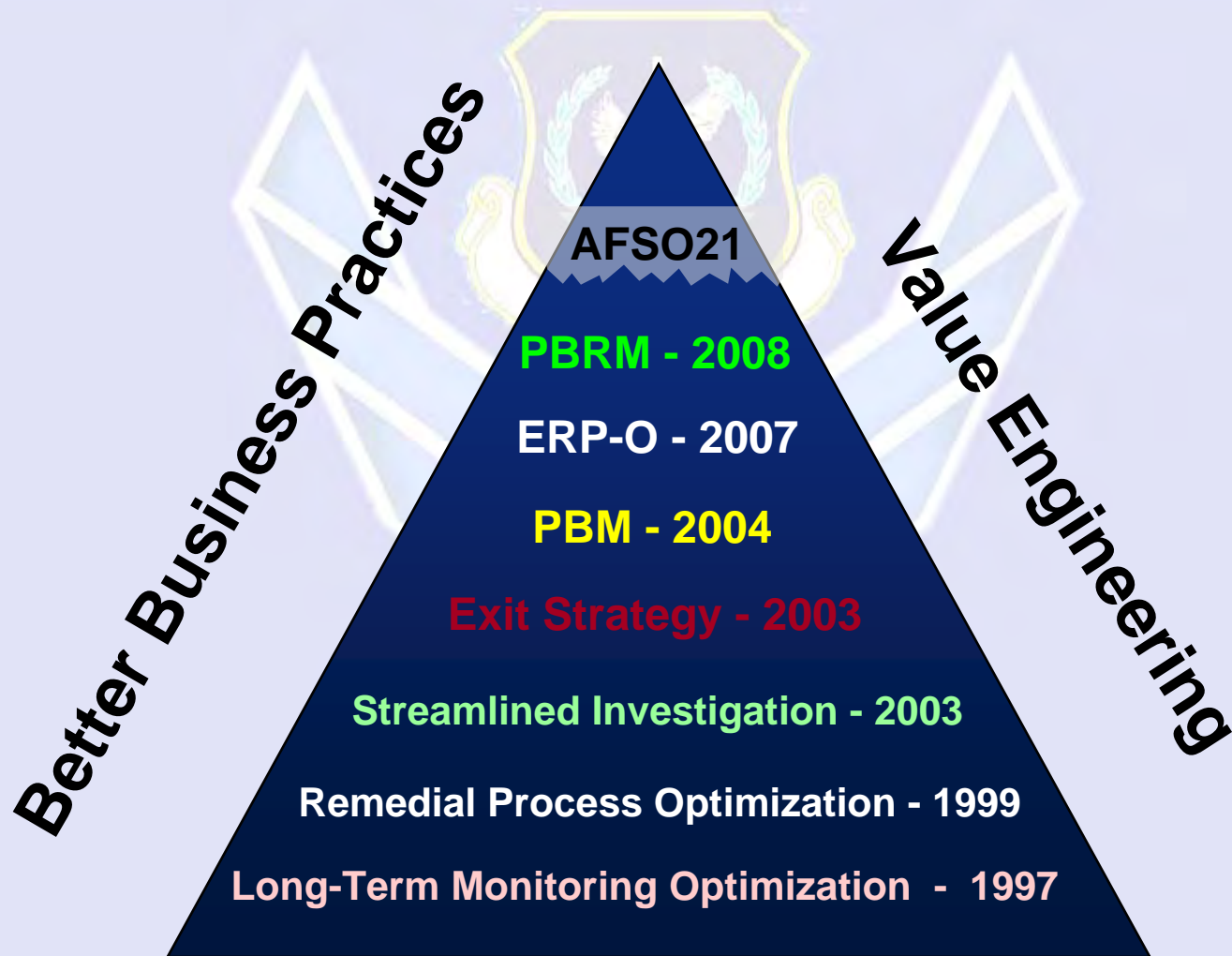
E2S2

May 6, 2009

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Foundation for ERP-O





ERP-O Definition

Definition:

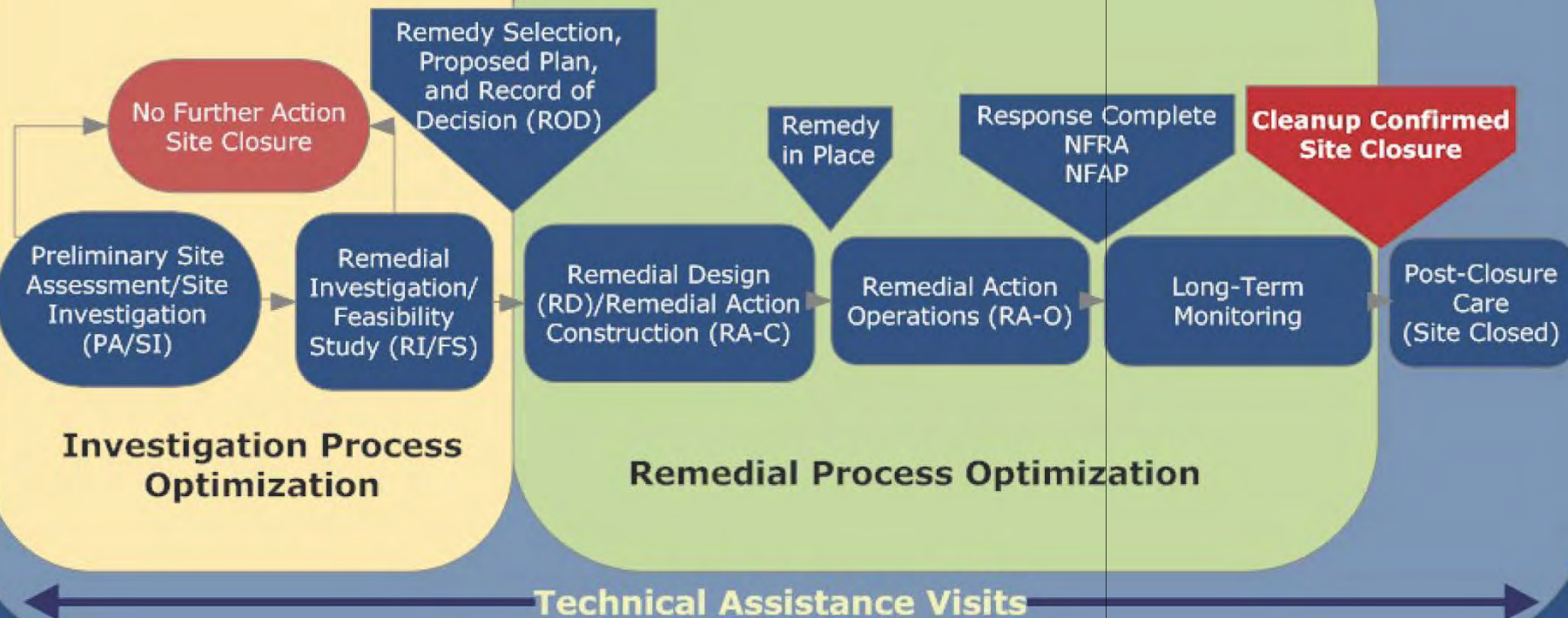
Environmental Restoration Program Optimization (ERP-O) is a comprehensive and systematic review of an installation's past, current and planned cleanup activities whose goal is to ensure protection of human health and the environment over the entire restoration life-cycle at minimal risk and optimal costs

ERP-O provides all the needed tools to manage risk and complies with AFSO21



ERP-O Flow Chart

Environmental Restoration Program Optimization





Investigation Process Optimization (IPO)

Definition:

**An Iterative/Systematic Planning Approach for
Evaluating Remedial Study Programs
with the Goal of Improving Overall:**

- ✓ **Study Program Effectiveness**
- ✓ **Time and Cost to Achieve Site RIP Milestone**
- ✓ **Timely Feedback to Decision Makers**

A component of the overall AFCEE ERP-O



Remedial Process Optimization (RPO)

Definition:

**An Iterative/Systematic Planning Approach for
*Evaluating Existing/Proposed Remediation
Processes* with the Goal of Improving Overall:**

- ✓ **Control Effectiveness**
- ✓ **Site Cleanup Time and Costs**
- ✓ **Timely Feedback to Decision Makers**

A component of the overall AFCEE ERP-O



Technical Assistance

Definition:

**A Systematic Analytical Approach for
*resolution of regulatory, technical, contractual,
programmatic issues***

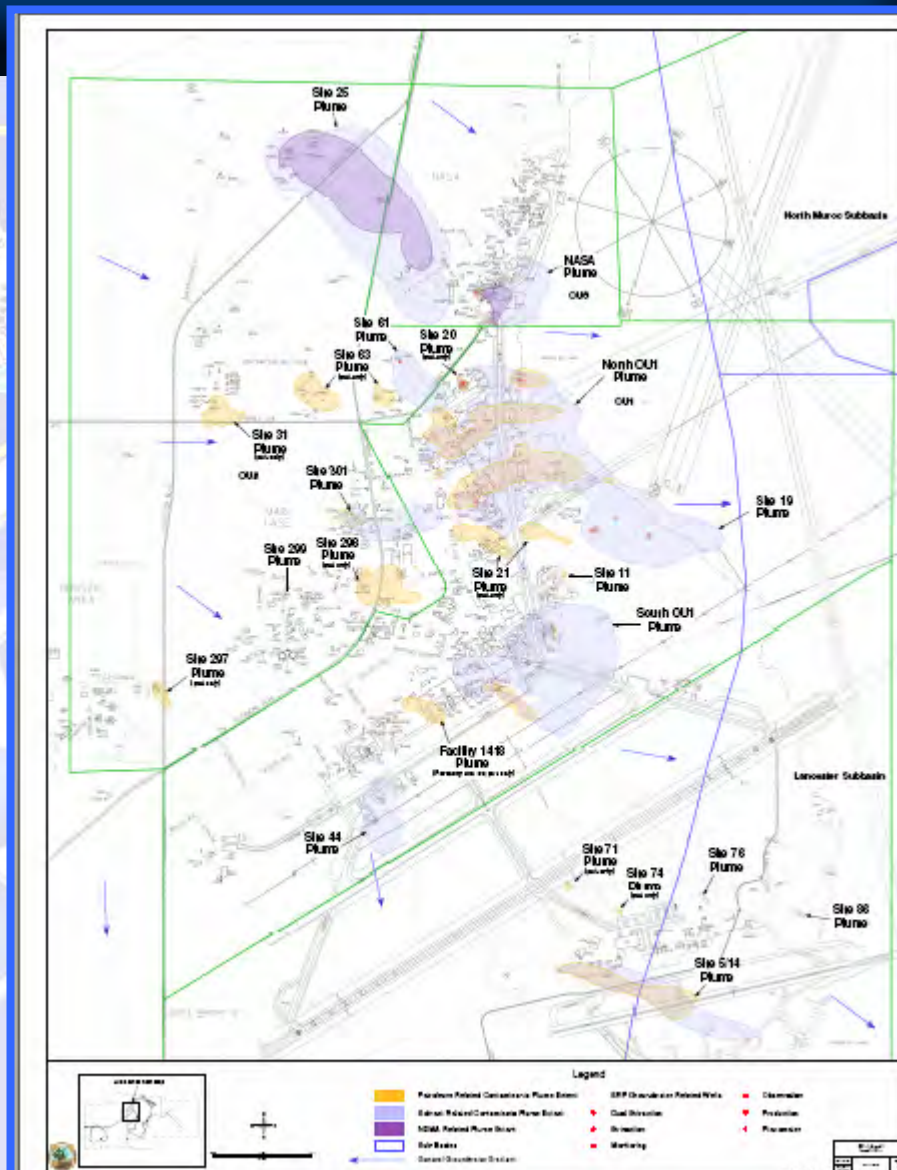
- ✓ **Conceptual Site Models and Exit Strategies**
- ✓ **Decision Documents**
- ✓ **Contractual Strategies**
- ✓ **Decision Logic**
- ✓ **Background Studies**

A component of the overall AFCEE ERP-O



Example Site: EAFB

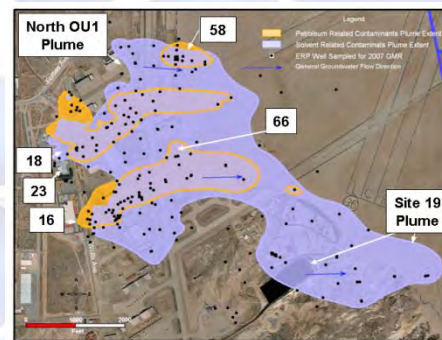
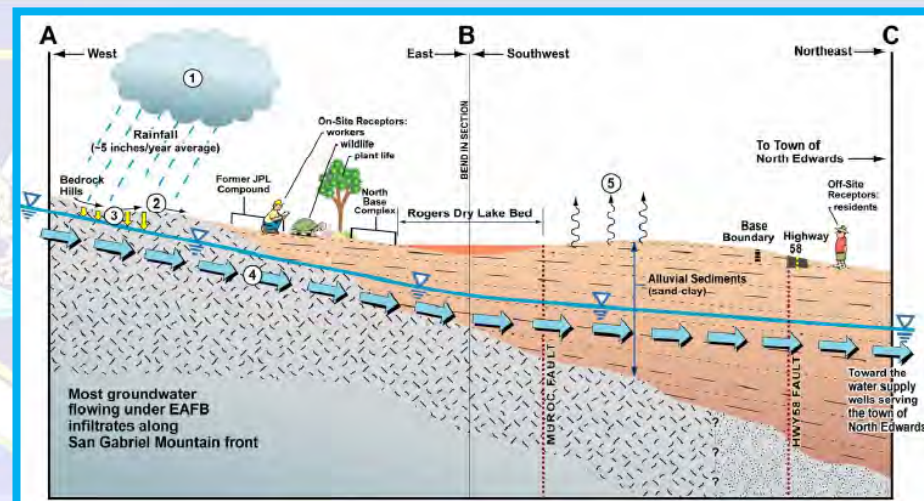
- Edwards Air Force Base
- Technical Impracticability waivers
- Base-related practices for over 50 years
- Several large plumes in complex geology including fractured bedrock
- A variety of cleanup technologies
- Chemicals of Concern:
 - ✓ TCE, BTEX, MTBE, Perchlorate, NDMA, etc.





EAFB : ERP-O Team Recommendations

- Continue Technical Impracticability waivers where applicable
- Establish a base-wide LTMO process, build an LTMO decision tree (based on a DQOs), and share with the RPMs
- Prepare a detailed performance monitoring plan to ensure that remedy maintains effectiveness and efficiency
- Consider an overall strategy that does not require perpetual extraction well network to contain the down-gradient migration of the plume

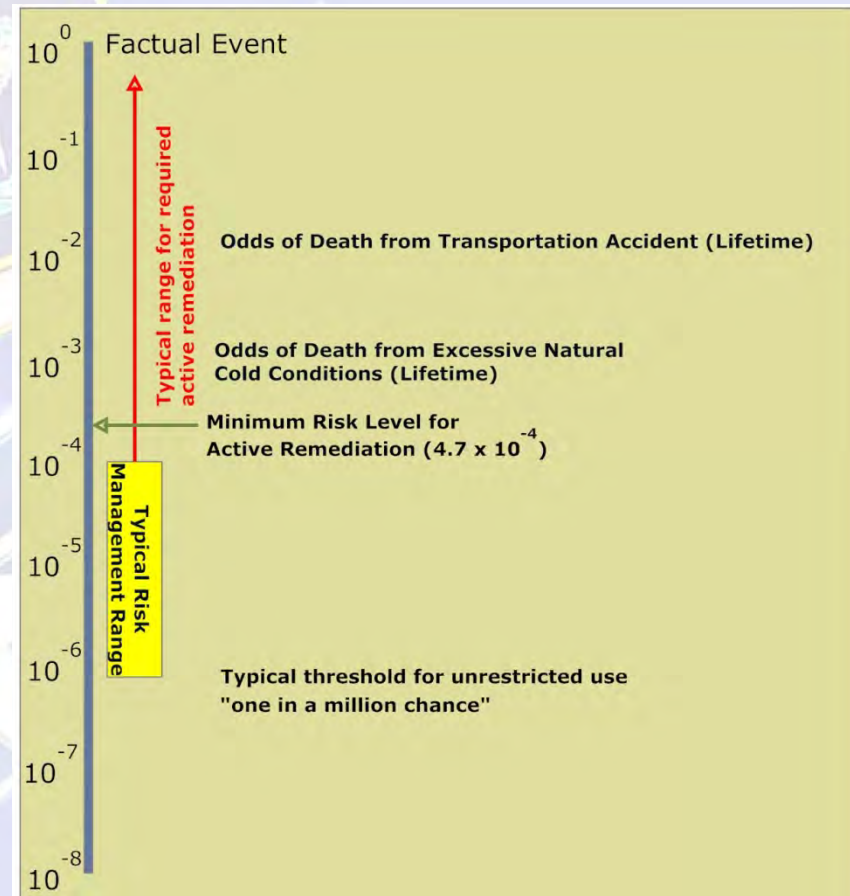




Example: Risk to Workers

Which site at which facility

- By operating the groundwater treatment system:
 - ✓ Risk to workers – 1×10^{-3}
 - ✓ Risk to community – 1×10^{-4}
- Risk to HH & Eco from ground water – 1×10^{-6}
- Is active remediation really justified?
 - ✓ Alternative to remediation





Resources Utilized vs. Resources Protected

Which site at which facility

- Evaluation of resources being protected
- Technology vs. Energy Use
- Is active remediation really justified?
 - ✓ Alternative to remediation

Groundwater restoration

California installation

Consuming 1.5M KWH/yr

**Removing < 50 grams of
TCE**

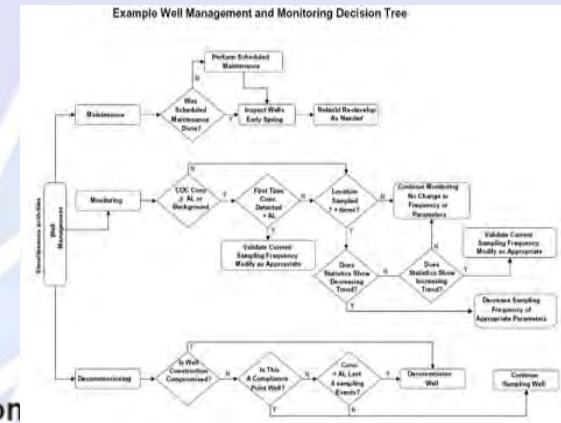
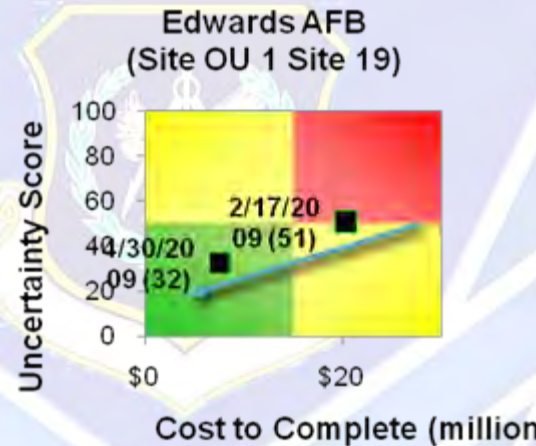
\$3.6M/lb removed



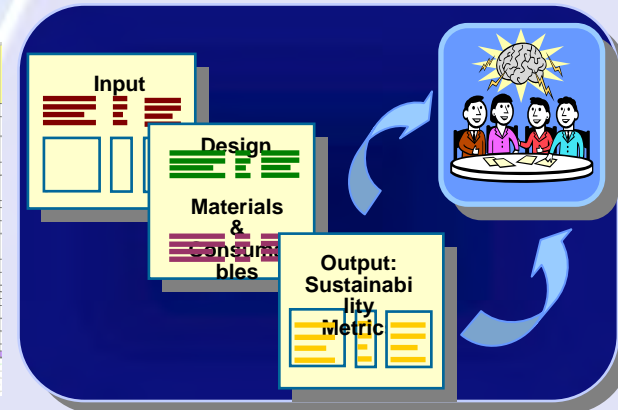
ERP-O Tools

Support Tools

- ✓ Uncertainty Tool
- ✓ Sustainability Tool
- ✓ Performance Tracking
- ✓ Recommendation Tracking
- ✓ LTMO



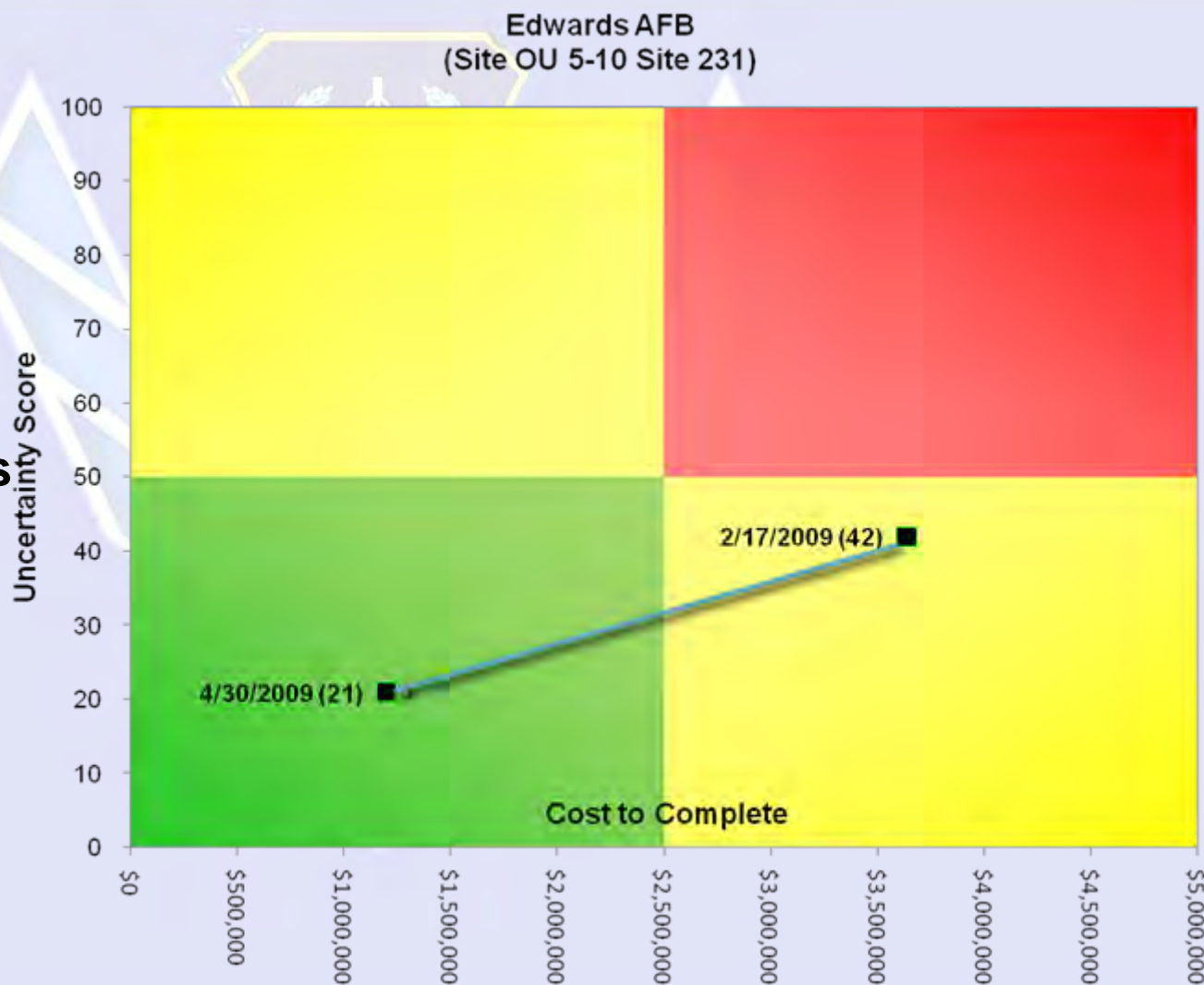
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Activity 1	Activity 1 Description	Activity 1 ID	Activity 1 Type	Activity 1 Status	Activity 1 Location	Activity 1 Date	Activity 1 Duration	Activity 1 Cost	Activity 1 Risk	Activity 1 Impact	Activity 1 Outcome	Activity 1 Metric	Activity 1 Score	Activity 1 Rating	Activity 1 Comment
Activity 2	Activity 2 Description	Activity 2 ID	Activity 2 Type	Activity 2 Status	Activity 2 Location	Activity 2 Date	Activity 2 Duration	Activity 2 Cost	Activity 2 Risk	Activity 2 Impact	Activity 2 Outcome	Activity 2 Metric	Activity 2 Score	Activity 2 Rating	Activity 2 Comment
Activity 3	Activity 3 Description	Activity 3 ID	Activity 3 Type	Activity 3 Status	Activity 3 Location	Activity 3 Date	Activity 3 Duration	Activity 3 Cost	Activity 3 Risk	Activity 3 Impact	Activity 3 Outcome	Activity 3 Metric	Activity 3 Score	Activity 3 Rating	Activity 3 Comment
Activity 4	Activity 4 Description	Activity 4 ID	Activity 4 Type	Activity 4 Status	Activity 4 Location	Activity 4 Date	Activity 4 Duration	Activity 4 Cost	Activity 4 Risk	Activity 4 Impact	Activity 4 Outcome	Activity 4 Metric	Activity 4 Score	Activity 4 Rating	Activity 4 Comment
Activity 5	Activity 5 Description	Activity 5 ID	Activity 5 Type	Activity 5 Status	Activity 5 Location	Activity 5 Date	Activity 5 Duration	Activity 5 Cost	Activity 5 Risk	Activity 5 Impact	Activity 5 Outcome	Activity 5 Metric	Activity 5 Score	Activity 5 Rating	Activity 5 Comment
Activity 6	Activity 6 Description	Activity 6 ID	Activity 6 Type	Activity 6 Status	Activity 6 Location	Activity 6 Date	Activity 6 Duration	Activity 6 Cost	Activity 6 Risk	Activity 6 Impact	Activity 6 Outcome	Activity 6 Metric	Activity 6 Score	Activity 6 Rating	Activity 6 Comment
Activity 7	Activity 7 Description	Activity 7 ID	Activity 7 Type	Activity 7 Status	Activity 7 Location	Activity 7 Date	Activity 7 Duration	Activity 7 Cost	Activity 7 Risk	Activity 7 Impact	Activity 7 Outcome	Activity 7 Metric	Activity 7 Score	Activity 7 Rating	Activity 7 Comment
Activity 8	Activity 8 Description	Activity 8 ID	Activity 8 Type	Activity 8 Status	Activity 8 Location	Activity 8 Date	Activity 8 Duration	Activity 8 Cost	Activity 8 Risk	Activity 8 Impact	Activity 8 Outcome	Activity 8 Metric	Activity 8 Score	Activity 8 Rating	Activity 8 Comment
Activity 9	Activity 9 Description	Activity 9 ID	Activity 9 Type	Activity 9 Status	Activity 9 Location	Activity 9 Date	Activity 9 Duration	Activity 9 Cost	Activity 9 Risk	Activity 9 Impact	Activity 9 Outcome	Activity 9 Metric	Activity 9 Score	Activity 9 Rating	Activity 9 Comment
Activity 10	Activity 10 Description	Activity 10 ID	Activity 10 Type	Activity 10 Status	Activity 10 Location	Activity 10 Date	Activity 10 Duration	Activity 10 Cost	Activity 10 Risk	Activity 10 Impact	Activity 10 Outcome	Activity 10 Metric	Activity 10 Score	Activity 10 Rating	Activity 10 Comment





Uncertainty Analysis Tool

- A series of questions
- Site-specific information
- Estimates based on ERP-O team recommendations
- Real reduction after reasonable time of implementation





SRT

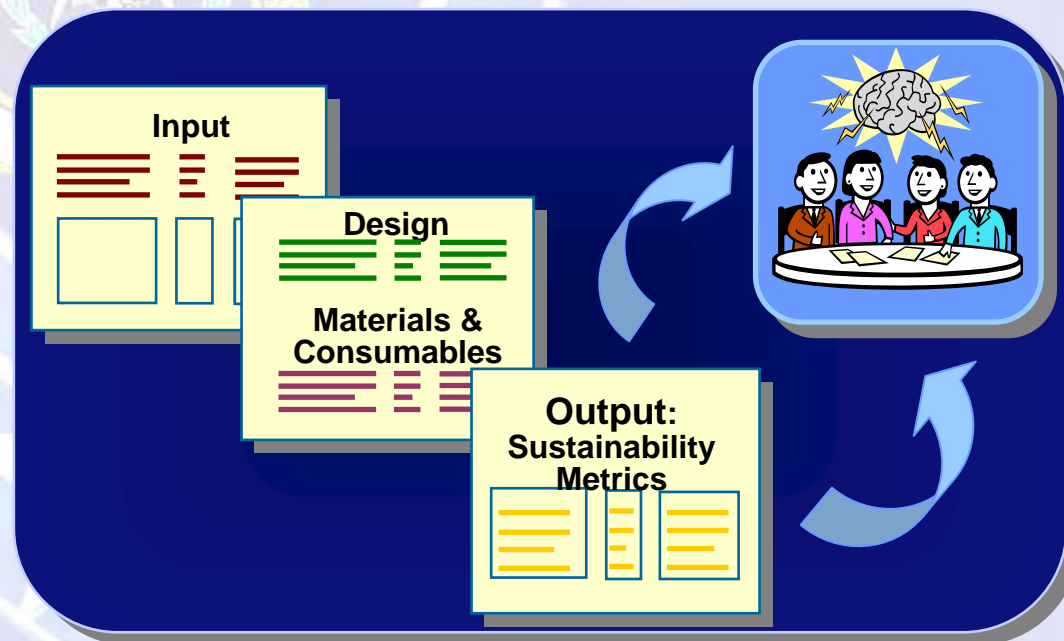
Which site at which facility

➤ **SRT estimates sustainable metrics for specific technologies**

- ✓ Excavation
- ✓ SVE
- ✓ P&T
- ✓ Enhanced Bioremed

➤ **Sustainable metrics developed**

- ✓ CO₂
- ✓ Energy Consumed
- ✓ Technology Cost
- ✓ Safety/Accident Risk





Performance Tracking Tool

Which site at which facility

- **Track Remedy's Performance and Cost**
 - ✓ Projected vs. actual for contaminant reduction
 - ✓ Projected cost vs. actual
- **Normalized output for easy comparisons**
- **Six Technologies**
 - ✓ Bioslurping
 - ✓ MNA
 - ✓ P&T
 - ✓ Surfactant Extraction
 - ✓ SVE
 - ✓ Dual – SVE & P&T

The interface is titled 'AFCEE Performance Tracking Tool' with the U.S. Air Force logo. It features a grid of buttons for different remediation technologies. The technologies listed are Bioslurp, MNA, P&T, Surfact Extract, SVE, and Dual SVE-P&T. Each technology has two buttons: 'Mass Calculation' and 'Cost & Restoration Performance'. The 'Dual SVE-P&T' technology has three buttons: 'Mass Calculation SVE', 'Mass Calculation P&T', and 'Cost & Restoration Performance'.

AFCEE Performance Tracking Tool	
Bioslurp	
Mass Calculation P&T	Cost & Restoration Performance
MNA	
Mass Calculation MNA	Cost & Restoration Performance
P&T	
Mass Calculation P&T	Cost & Restoration Performance
Surfact Extract	
Mass Calculation SurfactX	Cost & Restoration Performance
SVE	
Mass Calculation SVE	Cost & Restoration Performance
Dual SVE-P&T	
Mass Calculation SVE	Mass Calculation P&T
Cost & Restoration Performance	

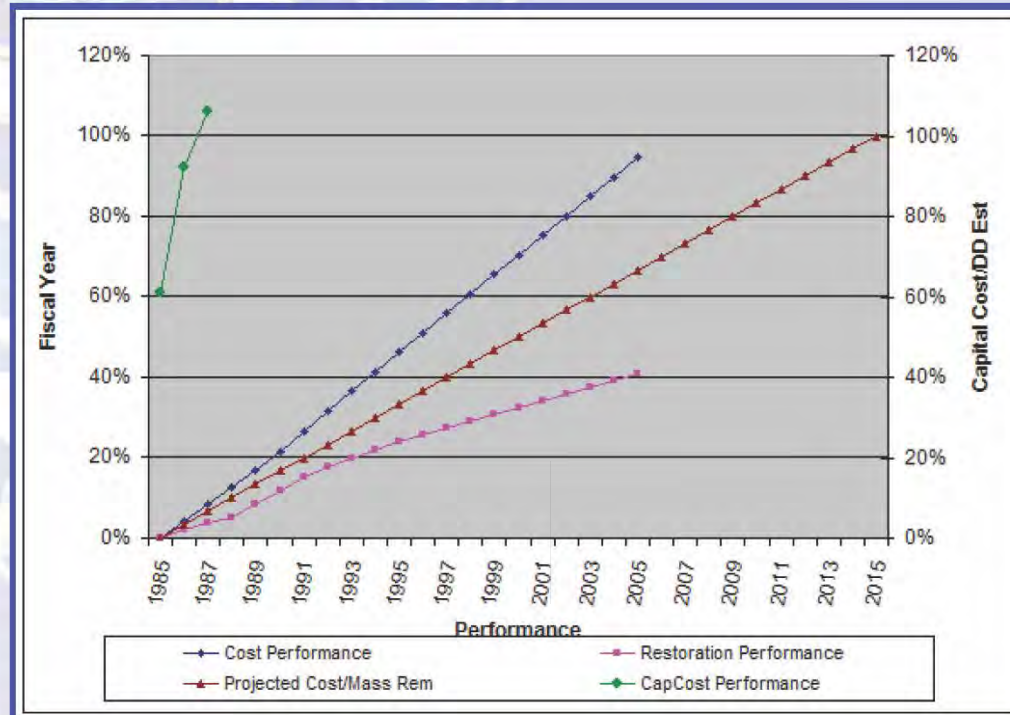


PTT

Capital Cost by Fiscal Year	Operation & Maintenance Cost by Fiscal Year	Projected Costs/Mass Removed (from DD)	Capital Cost as Percent DD Est.	O&M as Percent of CTC	Total Percent Mass Removed
\$ 195,000	\$ -	0%	61%	0%	0%
\$ 100,000	\$ 290,000	3%	92%	4%	2%
\$ 45,000	\$ 290,000	7%	106%	8%	4%
	\$ 300,000	10%		13%	5%
	\$ 310,000	13%		17%	8%
	\$ 305,000	17%		21%	12%
	\$ 375,000	20%		27%	15%
	\$ 340,000	23%		32%	18%
	\$ 340,000	27%		36%	20%
	\$ 340,000	30%		41%	22%
	\$ 340,000	33%		46%	24%
	\$ 340,000	37%		51%	26%
	\$ 340,000	40%		56%	27%
	\$ 340,000	43%		61%	29%
	\$ 340,000	47%		66%	31%
	\$ 340,000	50%		70%	32%
	\$ 340,000	53%		75%	34%
	\$ 340,000	57%		80%	36%
	\$ 340,000	60%		85%	37%
	\$ 340,000	63%		90%	39%
	\$ 340,000	67%		95%	41%
		70%			
		73%			
		77%			
		80%			
		83%			
		87%			
		90%			
		93%			
		97%			
		100%			

Total Mass at RA-O Start-Up (lb)	30000
Cost-To-Complete (CTC) (\$)	\$ 7,000,000
DD Capital Cost Est	\$ 320,000
Impacted Acres	23
Acre-ft of groundwater impacted	265
RA-O Start Year (from DD)	1985
RA-O Completion Year	2015

	To Date	Estimated total cost
Cost/Acre	\$ 288,261	\$ 117,832
Cost/Acre feet	\$ 25,019	\$ 10,227
Cost/lb removed	\$ 541	
Total O&M Costs	\$ 6,630,000	
Total Mass Removed	12,263 lbs	
Portion of DD Mass Rem	40.9%	





➤ Track Recommendations (ERP-O Phase IV)

Track

- ✓ **Implementation**
- ✓ **Risk reduction**
- ✓ **RC Acceleration**
- ✓ **Total Investment**
- ✓ **Cost avoidance**
- ✓ **ROI**

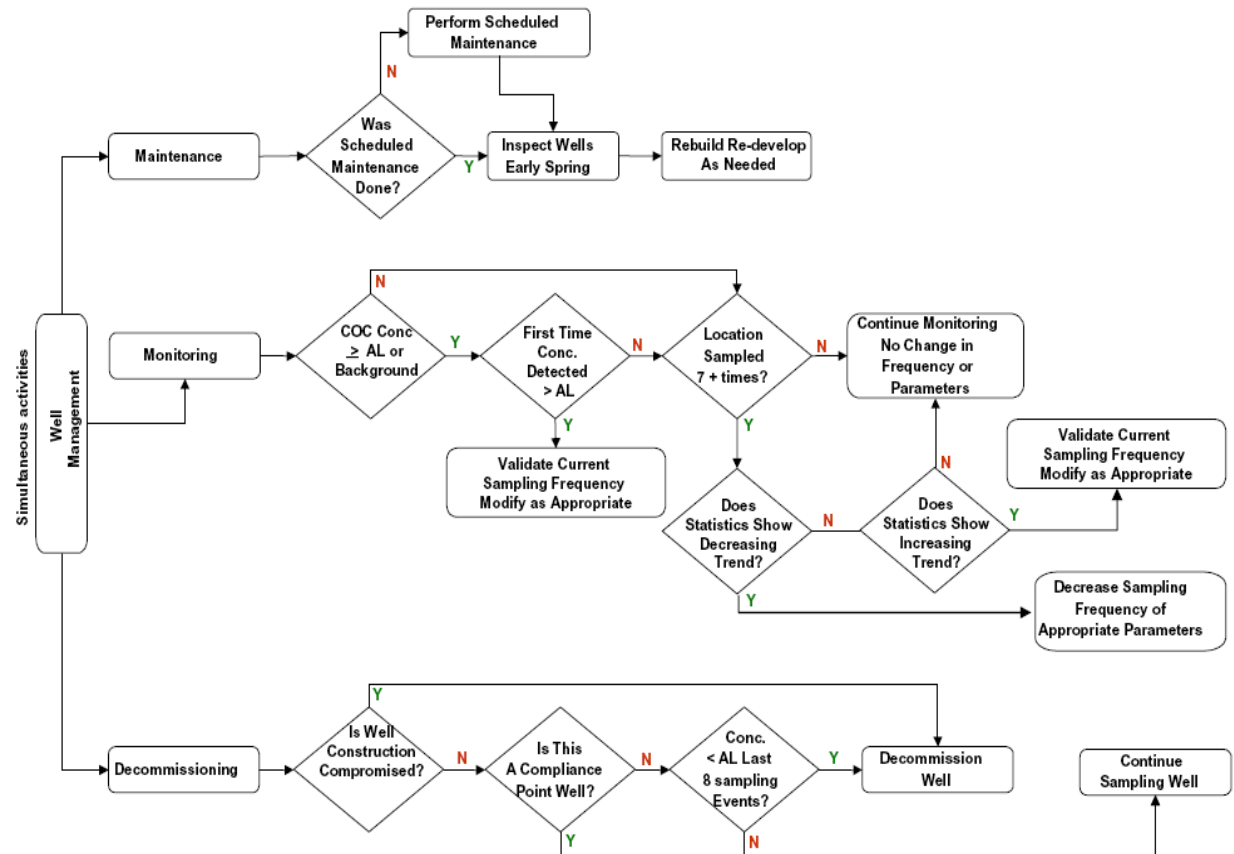
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Monitoring Decision Logic

- Purpose of each well?
- CoC trends
- Statistical analysis
- Rational recommendations

Example Well Management and Monitoring Decision Tree





Monitoring Decision Logic

Well ID	Current Sampling Frequency	Well purpose (e.g., water level, background, compliance monitoring, sentry well, plume monitoring, etc.)	Target Analytes/Methods (e.g., B2000, MHA, field parameters, etc.)	ISample results in historic trend and most recent sampling (V, TCE, PCA)	Qualitative Concentration Trends Most Wells Decreasing in Plume	Potentially spatially redundant or unnecessary	Recommended statistical temporal trend analysis?	Recommendation for future monitoring (e.g., frequency, analytical, sampling method, removal)	Rationale for recommendation	Comments
AP-374	semi-annual	sentry	VOCs by \$260B	21, ND, ND	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Down gradient of sentry well AP4019	All non detections since inception (21 sampling rounds)
AP-4011	semi-annual	PM	\$260B	19, 17, 1.3	Decreasing/Stable	AP4017 & AP4525	No	NO (Abandon)	Plume stability is confirmed	Only TCE remains above MCL after 19 rounds of sampling
AP-4017	semi-annual	PM	VOCs by \$260B	18, 1200, 230	Decreasing/Stable		No	YES (5 yr, TCE & PCA only)	Main plume monitoring well	Principal indicator of progress towards RAOs
AP-4019	semi-annual	sentry	VOCs by \$260B	18, ND, ND	Decreasing/Stable		No	YES (5 yr, TCE & PCA only)	To monitor plume stability and behavior	Sentry well to ensure the plume stability
AP-434	semi-annual	sentry	VOCs by \$260B	7, 15, nd	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Plume is stable	Sentry well has a well up gradient to monitor AP4525
AP-434	semi-annual	sentry	VOCs by \$260B	7, nd, nd	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Plume stability is confirmed	No detections of CoCr for over five years of sampling
AP-435	semi-annual	sentry	VOCs by \$260B	7, nd, nd	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Plume stability is confirmed	TCE, PCEND far ten years
AP-4525	semi-annual	PM	VOCs by \$260B	5, 600, 120	Decreasing/Stable		No	YES (5 yr, TCE & PCA only)	Plume monitoring	Principal indicator of progress towards RAOs
AP-455	semi-annual	PM	VOCs by \$260B	3, 19, 120	Decreasing/Stable	Spatially redundant with AP4017 & AP4525	No	NO (Abandon)	Plume is stable	TCE can be monitored from the wells AP4017 & AP4525
AP-524	semi-annual	sentry	VOCs by \$260B	1, nd, nd	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Plume stability is confirmed	No detections of CoCr
AP-374	semi-annual	PM	VOCs by \$260B	14, 56, 9	Decreasing/Stable	Spatially redundant with AP4017 & AP4525	No	NO (Abandon)	Up gradient of sentry monitoring well AP3747	All VOCs below action levels except for TCE & PCA
AP-374	semi-annual	side gradient	VOCs by \$260B	17, 29, 25	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Up gradient of sentry monitoring well AP3748	All VOCs below action levels except for TCE & PCA
AP-374	semi-annual	sentry	VOCs by \$260B	16, 250, 2.5	Decreasing/Stable		No	YES (5 yr, TCE & PCA only)	Monitoring of Sentry well	Sentry well to ensure the plume stability
AP-374	semi-annual	up gradient	VOCs by \$260B	18, ND, ND	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Up gradient clean well	
AP-398	semi-annual	Up gradient	VOCs by \$260B	14, 9.8, 2.5	Decreasing/Stable	Unnecessary	No	YES (5 yr, TCE & PCA only)	Plume stability is confirmed	No detections since 2000
AP-398	semi-annual	sentry	VOCs by \$260B	18, ND, ND	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Plume stability is confirmed	No detections since 2000
AP-398	semi-annual	PM	VOCs by \$260B	17, 2100, 720	Decreasing/Stable	Spatially redundant with AP4017 & AP4525	No	NO (Abandon)	Plume is stable	Well on either side AP3989 and AP4519 will suffice
AP-398	semi-annual	PM	VOCs by \$260B	17, 350, 53	Decreasing/Stable	Spatially redundant with AP4017 & AP4525	No	NO (Abandon)	Plume stability is confirmed	Other wells in the main plume area will continue to monitor
AP-398	semi-annual	PM	VOCs by \$260B	16, 250, 27	Decreasing/Stable	Spatially redundant with AP4017 & AP4525	No	NO (Abandon)	Plume is stable	Other wells in the main plume area will continue to monitor
AP-398	semi-annual	PM	VOCs by \$260B	18, 920, 200	Decreasing/Stable		No	YES (5 yr, TCE & PCA only)	To monitor plume stability and behavior	TCE and PCA can be monitored in this well to make future cleanup complete decision
AP-435	semi-annual	sentry	VOCs by \$260B	7, nd, nd	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Down gradient clean well	No detections since 2000
AP-435	semi-annual	Up gradient		7, 210, 62	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Plume stability is confirmed	Up gradient well
AP-435	semi-annual	Up gradient		7, nd, nd	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Up gradient clean well	No detections ever
AP-4519	semi-annual	side gradient		15, ND, ND	Decreasing/Stable	Unnecessary	No	NO (Abandon)	Side gradient clean well	No detections ever
AP-4519	semi-annual	PM		6, 1000, 350	Decreasing/Stable		No	YES (5 yr, TCE & PCA only)	Main plume monitoring well	TCE and PCA can be monitored in this well to make future cleanup complete decision
AP-455	semi-annual	PM		3, 1000, 330	Decreasing/Stable	Spatially redundant with AP4017 & AP4525	No	NO (Abandon)	Plume stability is confirmed	Other wells in the main plume area will continue to monitor



ERP-O Supporting Agencies

- **ITRC - Interstate Technology Regulatory Council**
 - ✓ **ITRC Team Members become Advocates for the Process**
- **USGS – US Geological Survey**
 - ✓ **Support CSM and fate and transport model oversight**
- **USACE – US Army Corp of Engineers**
 - ✓ **Additional DoD Technical Expertise**



ITRC RRM and GSR Teams

- **ITRC - Interstate Technology Regulatory Council**
- **AFCEE is providing in-kind support to several ITRC teams including Remediation Risk Management (RRM) and Green & Sustainable Remediation (GSR) Teams**
- **AFCEE Funds and Supports ITRC RPO Team Members to Participate on ERP-O Reviews**



ITRC RRM & GSR Team Products

- **RPO Products on www.itrcweb.org**
 - ✓ **RPO and PBEM Technical Guidance Documents**
 - ✓ **RPO related Fact Sheets**
 - ✓ **RPO and PBEM Internet-based Trainings**
- **ITRC RRM Team Products**
 - ✓ **Technical & Regulatory Guidance Document (Fall '09)**
 - ✓ **Internet-based Training on RRM (Early 2010)**
- **ITRC GSR Team Products**
 - ✓ **Status summary of GSR practices**
 - ✓ **State survey of GSR practices**
 - ✓ **Technical and Regulatory Guidance Document (2010)**
 - ✓ **Internet-based Training on GSR (2011)**



Incorporating Sustainable and Green Practices into ERP-O

- **AFCEE PBM Guidance document is being developed to reflect ERP-O Strategies and sustainable remediation**
 - ✓ **PBRM a green/sustainable process is also being revised**
 - ✓ **PBM, ERP-O, IPO, RPO, PBRM all have a common goal**
 - **Sustainable, green, & cost effective RIP by 2012**
 - **Accelerate clean closure**
- **Investigation Processes**
 - ✓ **Use more sustainable approaches for characterization**
 - ✓ **Use Triad with a green perspective**
- **Land Use and Institutional Controls**
 - ✓ **Developing sustainable strategies with the active participation from stakeholders**



Integrity - Service - Excellence